Appendicitis
Rita A. Manfredi and Claudia Ranniger

ANATOMY
The appendix is a tubular structure that arises from the cecum and consists primarily of smooth muscle and an abundance of lymphoid tissue. The average adult appendix can reach a length of 10 cm with a luminal width of 6 to 7 mm. Innervation from sympathetic and vagus nerves accounts for referred pain to the umbilicus when inflammatory changes are present. The location of the appendix (retrocecal, 65%; pelvic, 31%; subcecal, 2%) determines the clinical findings and risk for the development of perforated appendicitis.

PATHOPHYSIOLOGY
Acute appendicitis develops as a result of luminal obstruction, which promotes bacterial overgrowth and distention. Obstruction of the appendiceal lumen is commonly caused by fecal stasis and fecaliths; other obstructive masses include lymphoid hyperplasia, vegetable matter, fruit seeds, intestinal worms, inspissated radiographic barium, and tumors (e.g., carcinoid). Luminal obstruction creates a closed space in which bacterial overgrowth leads to the accumulation of fluid and gas. Organisms are typically polymicrobial, with a predominance of anaerobic and gram-negative species.

As the appendix distends, normal circulatory supply is impaired and the inflammatory changes worsen. Ischemia, infarction, and perforation can ensue. Progression of an inflamed appendix from gangrene to perforation is variable, with a mean duration of abdominal symptoms of between 2 days (gangrene) and 3 days (perforation).

CLINICAL PRESENTATIONS
CLASSIC
The pain of acute appendicitis starts as diffuse, poorly localized, periumbilical discomfort (visceral pain) that localizes to the McBurney point in the right lower quadrant over a period of 12 to 24 hours (peritoneal pain). The McBurney point is located one third of the distance from the right anterior superior iliac crest to the umbilicus. The appendix is located within 5 cm of the McBurney point in only 50% of patients.

Once the pain is perceived in the right lower quadrant, sudden movements cause severe discomfort consistent with localized peritonitis. Associated symptoms often include anorexia, nausea, and vomiting. Diarrhea is uncommon, although patients may report an increasing urge to defecate (the “downward urge”). Bowel movements or the passage of flatus does not relieve the pain, however.
Up to 50% of patients have a normal body temperature on initial arrival at the ED.\textsuperscript{1} Patients with significant inflammation prefer to remain still in an effort to minimize peritoneal irritation. The right leg may be flexed at the hip to further decrease peritoneal stretch (see Table 39.1, Special Maneuvers That Suggest Appendicitis, online at www.expertconsult.com). Palpation of the abdomen generally reveals localized right lower quadrant tenderness. Rebound tenderness, voluntary and involuntary guarding, and rigidity may be observed, depending on the extent of appendiceal inflammation.

**Physical signs and symptoms vary with the location of the appendix.** If the appendix is retrocecal, pain and tenderness may localize to the flank and not to the right lower quadrant. A retrocecal appendix in men or boys may irritate the ureter with resulting radiation of pain to the testicle. The gravid uterus of a pregnant patient was previously thought to displace the appendix superiorly as the pregnancy progresses and cause right upper quadrant or flank pain. However, recent studies suggest that this conventional belief may be incorrect and that the location of the appendix may be similar in pregnant and nonpregnant patients.\textsuperscript{4,5} A pelvic appendix may irritate the bladder or rectum and result in dysuria, suprapubic pain, or a more pronounced urge to defecate. If the appendix is low lying, isolated rectal tenderness may be the only sign.\textsuperscript{6}

**VARIATIONS**

**Children**

Appendicitis is the most common condition requiring emergency abdominal surgery in children. Up to 8% of children seen in the ED with abdominal pain have appendicitis. In the very young, appendicitis is quite uncommon because the appendix is funnel shaped and less prone to obstruction. Symptoms of appendicitis in this age group are nonspecific and mimic those of gastroenteritis, viral syndrome, and intussusception. The incidence of appendicitis rises with age, but the likelihood of perforation is highest in infants. Neonatal appendicitis has a high mortality rate. Almost 100% of children younger than 2 years have a perforated appendix at the time of diagnosis. In children 3 to 5 years of age the perforation rate is 71%, and in children 6 to 10 years of age the rate is 40%. Appendicitis most frequently occurs in patients between 10 and 20 years old.

Children with appendicitis commonly exhibit fever and vomiting. These two signs, along with abdominal distention, are most often seen in infants. A leathargic, irritable baby with grunting respirations may be a typical manifestation in this age group. Toddlers are more likely to have vomiting and fever followed by pain. In school-age children, vomiting and abdominal pain are the more frequent symptoms.\textsuperscript{6} When the diagnosis is unclear, one should avoid diagnosing acute gastroenteritis in young children without diarrhea.

In the vast majority of children, the diagnosis of appendicitis is made only after perforation occurs, possibly because of a child’s inability to describe the pain or the physician’s misattribution of symptoms to other childhood diseases or to gastroenteritis. As a result of perforation, worsening peritonitis in children might be manifested as lethargy, inactivity, and hypothermia.\textsuperscript{7}

Adolescent girls are a subset of the pediatric population that deserves special attention in the evaluation of acute appendicitis. The etiology of right lower quadrant pain in prepubertal and postpubertal girls includes ovarian torsion, ovarian cyst, intrauterine pregnancy, and ectopic pregnancy. A urine pregnancy test followed by pelvic ultrasonography may be helpful in distinguishing ovarian pathology from appendicitis.\textsuperscript{8}

**Elderly**

Elderly patients are often initially seen late in the course of the disease and are three times more likely than the general population to have perforated appendicitis. The elderly have a higher incidence of early perforation (up to 70%) because of the anatomic changes in the appendix that occur with age, such as thinner mucosal lining, decreased lymphoid tissue, a narrowed appendiceal lumen, and atherosclerosis.\textsuperscript{8} A definitive diagnosis is often difficult to make because of associated comorbid conditions and the possibility of immunosuppression. Appendicitis accounts for 7% of abdominal pain in the elderly. Geriatric patients most commonly have an atypical manifestation and delay seeking medical intervention.\textsuperscript{9} In patients older than 70 years, the mortality rate is higher than 20% because of diagnostic and therapeutic delays.\textsuperscript{10} The majority of older patients with acute appendicitis are afebrile and do not have leukocytosis. When the clinical, laboratory, and imaging findings are equivocal, a low threshold for surgical consultation and inpatient observation must be considered for elderly patients with abdominal pain.

**Pregnant Women**

Appendicitis is the most common extraterine surgical emergency during pregnancy. Diagnosis of appendicitis in pregnancy is difficult because the appendix migrates upward as the uterus enlarges, so the location of pain or tenderness is variable. Early symptoms of appendicitis, particularly nausea and vomiting, are common in pregnancy. Leukocytosis is also a normal finding in pregnancy and does not aid in the differentiation of appendicitis, although an increase in band cells implies the presence of infection.

Pregnancy appears to have a protective effect on the development of appendicitis, especially in the third trimester.\textsuperscript{2} A fetal loss rate of up to 5% is seen in patients with unruptured appendicitis. Maternal death from appendicitis is extremely rare; however, perforation and subsequent peritonitis cause fetal mortality to rise to 30% and maternal mortality to 2%. The use of ultrasonography may differentiate obstetric causes of abdominal pain from appendicitis without the need for imaging studies that involve radiation, such as computed tomography (CT). Once the diagnosis of appendicitis has been made in a pregnant patient, urgent surgical exploration should be performed.\textsuperscript{11}

**Nonpregnant Women**

Gynecologic causes of lower abdominal pain often mimic appendicitis.\textsuperscript{10} Up to 45% of women who appear to have appendicitis on clinical examination are found to have a normal appendix at surgery. The highest percentage of misdiagnosis occurs in women of childbearing age.

**DIFFERENTIAL DIAGNOSIS**

When a patient complains of abdominal pain, suspicion for appendicitis, whether high or low, should be present in the
<table>
<thead>
<tr>
<th>Maneuver</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rovsing sign</td>
<td>With the patient in the supine position, palpation of the left lower quadrant causes pain in the right lower quadrant.</td>
</tr>
<tr>
<td>Psoas sign</td>
<td>With the patient in the left lateral decubitus position, extension of the right hip increases pain in the right lower quadrant (when an inflamed appendix is overlying the right psoas muscle).</td>
</tr>
<tr>
<td>Obturator sign</td>
<td>With the patient in the supine position, internal rotation of a passively flexed right hip and knee increases right lower quadrant pain.</td>
</tr>
</tbody>
</table>
The differential diagnosis for acute appendicitis is extensive and includes all causes of an acute abdomen (Box 39.1). Given that atypical manifestations in children, pregnant women, and the elderly are not uncommon, a high index of suspicion and early surgical consultation are critical.\(^2\)

### BOX 39.1 Differential Diagnosis of Acute Appendicitis

<table>
<thead>
<tr>
<th>Category</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Women</strong></td>
<td>Pelvic inflammatory disease and salpingitis</td>
</tr>
<tr>
<td></td>
<td>Ruptured ovarian cyst</td>
</tr>
<tr>
<td></td>
<td>Ovarian and adnexal torsion</td>
</tr>
<tr>
<td></td>
<td>Endometriosis</td>
</tr>
<tr>
<td></td>
<td>Ectopic pregnancy</td>
</tr>
<tr>
<td></td>
<td>Tuboovarian abscess</td>
</tr>
<tr>
<td><strong>Men</strong></td>
<td>Testicular torsion</td>
</tr>
<tr>
<td></td>
<td>Epididymitis and orchitis</td>
</tr>
<tr>
<td><strong>Men and Women</strong></td>
<td>Nephrolithiasis</td>
</tr>
<tr>
<td></td>
<td>Urinary tract infection and pyelonephritis</td>
</tr>
<tr>
<td></td>
<td>Diverticulitis</td>
</tr>
<tr>
<td></td>
<td>Inflammatory bowel disease (terminal ileitis in Crohn disease)</td>
</tr>
<tr>
<td></td>
<td>Infectious enteritis and colitis</td>
</tr>
<tr>
<td></td>
<td>Incarcerated hernia</td>
</tr>
<tr>
<td></td>
<td>Mesenteric adenitis</td>
</tr>
<tr>
<td><strong>Elderly Patients</strong></td>
<td>Diverticulitis</td>
</tr>
<tr>
<td></td>
<td>Mesenteric ischemia</td>
</tr>
<tr>
<td></td>
<td>Vascular disease</td>
</tr>
</tbody>
</table>

### DIAGNOSTIC TESTING

No single diagnostic test can reliably confirm or exclude the diagnosis of appendicitis. Diagnostic testing should not delay surgical consultation for patients with worrisome findings on examination. The surgeon should be engaged immediately (before laboratory testing or imaging) for a patient with an acute abdomen or when appendicitis is the most likely clinical diagnosis (Box 39.2).

The goals of testing are to improve accuracy and speed of diagnosis, exclude alternative causes of abdominal pain, and reduce the rate of appendectomies performed in patients who have a normal appendix (negative appendectomy rate).

### LABORATORY TESTING

Elevations in the white blood cell (WBC) count, percentage of bands, absolute neutrophil count, and C-reactive protein (CRP) level have each been associated with a greater likelihood of appendicitis. Taken individually, these tests have poor predictive value.\(^7\) In combination, elevated WBC and CRP values have been associated with positive likelihood ratios between 7 and 23 for the prediction of appendicitis in both children and adults.\(^13,14\) The likelihood of appendicitis when both WBC and CRP values are in the normal range is low.\(^15,16\) However, CRP and WBC values vary with age and the duration of symptoms; patients who are seen early in the disease process may have a normal CRP level.

Scoring systems that include historical data, physical findings, and laboratory markers have been developed to assist in differentiating appendicitis from other sources of abdominal pain. However, the sensitivity and specificity of these systems are not sufficient to predict the presence or absence of appendicitis with adequate reliability. These tools are more frequently used to risk-stratify patients who may need further diagnostic testing or observation.\(^17-21\)

It is imperative that pregnancy be excluded early in the assessment of a woman of childbearing age by checking a urine or serum quantitative human chorionic gonadotropin level.

An abnormal urinalysis result must be interpreted with caution in a patient with suspected appendicitis and a low likelihood of cystitis. Abnormal urinalysis results (including more than 4 red blood cells [RBCs] per high-power field [HPF], more than 4 WBCs per HPF, or proteinuria greater than 0.5 g/L) are observed in 36% to 50% of patients with acute appendicitis.\(^22\) These findings are more common in women, in patients with perforated appendicitis, and in patients in whom

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**Laboratory Testing**

Exclude pregnancy in women of childbearing age. The combination of an elevated white blood cell count and C-reactive protein has a high positive predictive value in patients in whom appendicitis is suspected.

**Imaging Studies**

- **Computed Tomography**
  - Abdominal-pelvic and focused appendiceal study protocols are available.
  - Use oral, rectal, or intravenous administration of contrast agents as needed; discuss with the radiologist.

- **Ultrasonography**
  - Ultrasound is the preferred modality for children, pregnant women, and nonpregnant women in whom concern for pelvic disease is high.
  - A diagnostic strategy of ultrasound and then computed tomography may decrease radiation exposure in patients with an uncertain diagnosis.

- **Plain Radiographs**
  - Plain films are not indicated for evaluation of appendicitis.
  - They are useful to exclude pneumoperitoneum, bowel obstruction, and foreign body.

- **Magnetic Resonance Imaging**
  - Consider in patients in whom computed tomography is contraindicated and other studies are nondiagnostic.

**See additional information on this topic, Table 39.2, Common Appendicitis Scoring Systems, and Table 39.3, Interpretation of Common Appendicitis Scoring Systems, online at www.expertconsult.com.**

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**Table 39.2 Common Appendicitis Scoring Systems**

<table>
<thead>
<tr>
<th>Scoring System</th>
<th>Components</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix Score</td>
<td>Clinical presentation, WBC, CRP</td>
<td></td>
</tr>
</tbody>
</table>
APPENDICITIS SCORING SYSTEMS

Difficult-to-diagnose cases of appendicitis are those that are manifested atypically. Appendicitis scoring systems based on historical data, physical examination, and laboratory results have been derived to decrease diagnostic uncertainty. No single test is able to identify appendicitis reliably. The utility of the scores lies in determining which patients can be safely sent home without imaging and, conversely, which patients should go to the operating room without delay. Most scores presented here stratify the patient population into a low, indeterminate, or high probability of having appendicitis.

The measures of a score’s efficacy are its sensitivity (which documents how well the score identifies all individuals with appendicitis) and its specificity (which documents how well the score excludes those without appendicitis). The sensitivities reported here are calculated from the number of individuals with and without appendicitis when using the low-probability cutoff. The specificities are calculated from the number of individuals with and without appendicitis when using the high-probability cutoff. The measure of a score’s utility can also be assessed by the proportion of patients who remain in the indeterminate group—that is, the group that requires additional resources and imaging for diagnosis. All patients in indeterminate groups should be further evaluated either through diagnostic imaging or by observation, at the discretion of the treating clinician.

Table 39.2 presents some common appendicitis scoring systems. Table 39.3 presents cutoff values, sensitivities and specificities, and size of the indeterminate group for these same scoring systems. Please note that the scoring systems have been applied in many more settings than can reasonably be presented here and that the accuracy of the scoring systems may vary significantly by study. In particular, the Alvarado score, developed in 1986, has been studied extensively.

Sensitivities and specificities vary among studies that apply the same scoring system. Confounding variables include differences in patient age (in some pediatric studies, for example, children younger than 4 years are not included because the historical symptoms cannot be scored), differences in inclusion criteria (e.g., excluding patients with pain for more than 7 days), or differences in the prevailing rate of appendicitis in the study cohort (ranging from 20% to 80%). It is important to understand the demographics of your own patient population when applying these scoring systems.
## Table 39.2 Common Appendicitis Scoring Systems

<table>
<thead>
<tr>
<th></th>
<th><strong>ALVARADO (MANTRELS) SCORE</strong></th>
<th><strong>APPENDICITIS INFLAMMATORY SCORE</strong></th>
<th><strong>PEDIATRIC APPENDICITIS SCORE</strong></th>
<th><strong>LINTULA SCORE</strong></th>
<th><strong>KHARABANDA SCORE</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Historical and symptoms</strong></td>
<td>Migratory RLQ pain</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Anorexia</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Migration of pain</td>
</tr>
<tr>
<td></td>
<td>Nausea or vomiting</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Vomiting</td>
</tr>
<tr>
<td><strong>Signs</strong></td>
<td>RLQ tenderness</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>Rebound tenderness</td>
</tr>
<tr>
<td></td>
<td>Rebound tenderness</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>Cough, percussion or hop tenderness</td>
</tr>
<tr>
<td></td>
<td>T &gt; 37.3°C</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>T &gt; 37.5°C</td>
</tr>
<tr>
<td></td>
<td>T ≥ 38.5°C</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>Unable to walk or walks with a limp</td>
</tr>
<tr>
<td><strong>Laboratory</strong></td>
<td>WBC &gt; 10 × 10⁹/L</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>ANC &gt; 6.75 × 10⁹/L</td>
</tr>
<tr>
<td></td>
<td>PMN proportion &gt; 75%</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>≥15 × 10⁹/L</td>
</tr>
<tr>
<td></td>
<td>PMN proportion</td>
<td></td>
<td>1</td>
<td>1</td>
<td>≥15 × 10⁹/L</td>
</tr>
<tr>
<td></td>
<td>CRP</td>
<td></td>
<td>1</td>
<td>1</td>
<td>≥50 g/L</td>
</tr>
</tbody>
</table>

**Maximum possible score**

ANC, Absolute neutrophil count; PMN, polymorphonuclear cell count; RLQ, right lower quadrant; WBC, white blood cell count.
### Table 39.3 Interpretation of Common Appendicitis Scoring Systems

<table>
<thead>
<tr>
<th></th>
<th>ALVARADO (MANTRELS)</th>
<th>APPENDICITIS INFLAMMATORY SCORE</th>
<th>PEDIATRIC APPENDICITIS SCORE</th>
<th>LINTULA SCORE</th>
<th>KHARABANDA SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum score</strong></td>
<td>10</td>
<td>12</td>
<td>10</td>
<td>34</td>
<td>14</td>
</tr>
<tr>
<td><strong>Intended interpretation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;6 = high probability</td>
<td>&lt;5 = low probability</td>
<td>&lt;3 = low probability</td>
<td>&lt;16 = low probability</td>
<td>&lt;6 = low risk</td>
</tr>
<tr>
<td></td>
<td>5-8 = indeterminate</td>
<td>3-8 = indeterminate</td>
<td>16-20 = indeterminate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;8 = high probability</td>
<td>&gt;8 = high probability</td>
<td>&gt;21 = high probability</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Real-world results (see discussion for interpretation)</strong></td>
<td>McKay:</td>
<td>Andresson:</td>
<td>Bhatt (using above cutoffs):</td>
<td>Goldman:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;4 = low probability</td>
<td>Sensitivity = 96%</td>
<td>Sensitivity = 97%</td>
<td>Sensitivity = 87%</td>
<td>Sensitivity = 96%</td>
</tr>
<tr>
<td></td>
<td>4-6 = indeterminate</td>
<td>Specificity = 99%</td>
<td>Specificity = 95%</td>
<td>Specificity = 59%</td>
<td>Specificity = 96%</td>
</tr>
<tr>
<td></td>
<td>&gt;6 = high probability</td>
<td>Sensitivity = 78%</td>
<td>Specificity = 95%</td>
<td>No data on number of patients in indeterminate group</td>
<td>77% of patients not in low-risk group</td>
</tr>
<tr>
<td><strong>Proportion of patients requiring further evaluation</strong></td>
<td>38% indeterminate</td>
<td>37% indeterminate</td>
<td>25% (Goldman)</td>
<td>Unknown</td>
<td>77% not in low-risk group</td>
</tr>
<tr>
<td></td>
<td>54% (Bhatt) indeterminate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NPV, Negative predictive value.
the appendix is located near the urinary tract. No upper limit of urinary WBC or RBC counts has been defined for appendicitis.

IMAGING

Plain Radiographs

Plain abdominal radiography is not indicated for the evaluation of potential appendicitis. Barium-enhanced imaging (via oral or rectal administration) demonstrates equally poor sensitivity because of nonfilling of the appendix and therefore has no role in the diagnosis of acute appendicitis. Plain radiography should be performed only to exclude suspected pneumoperitoneum, bowel obstruction, or foreign body.

Helical Computed Tomography

High-resolution helical CT is the diagnostic test of choice for suspected appendicitis (Fig. 39.1). CT findings in appendicitis include an appendiceal diameter greater than 7 to 10 mm, wall enhancement, wall thickening greater than 3 mm, and periappendiceal fat stranding.\(^{23,24}\) The reported sensitivity and specificity of helical CT for appendicitis in adults range between 91% and 96% and 90% and 95%, respectively.\(^{25-28}\)

The use of CT as a diagnostic tool for suspected appendicitis has grown explosively in recent years, with adult imaging rates in the United States reported to be greater than 90%.\(^{29-31}\) CT imaging is correlated with a significant decrease in the negative appendectomy rate to less than 9%\(^{29,32,33}\). The highest benefit of CT in reducing the negative appendectomy rate is appreciated in adult women.\(^{30,31}\) In the elderly, who often have atypical symptoms, the use of helical CT aids in early diagnosis and has reduced the rate of perforated appendicitis from 72% to 51%.\(^9\)

Intravenous, rectal, or oral administration of a contrast agent to enhance CT imaging in patients with suspicion of appendicitis is controversial. Variations in patient population, contrast protocol, scanner resolution, and radiation dosing all contribute to reported diagnostic accuracy. Contrast agent administered enterally or intravenously enhances the appendiceal wall, lumen, and periappendiceal fat, thereby improving visualization of adjacent intraperitoneal organs. An intravenously administered contrast agent can provide valuable information in patients with little visceral fat but may cause allergic reactions or exacerbate renal insufficiency.\(^{34}\) An enterally administered contrast agent is particularly useful in the identification of perforation, but oral administration of a contrast agent may exacerbate nausea, and 1 to 2 hours is required for the contrast agent to traverse the gut before imaging. Newer-generation multislice CT systems have improved image resolution, even without contrast enhancement. Judicious use of non–contrast-enhanced protocols may reduce diagnostic delays and avoid potential contrast agent–related morbidity.\(^{35,37}\)

Radiation exposure may be limited by using a focused appendiceal (right lower quadrant) CT study. Such protocols may be desirable for children and pregnant women, in whom large radiation exposure is a concern, but other intraabdominal disease may be missed. In children, the sensitivity of helical CT for appendicitis with contrast enhancement is 92% to 100% and the specificity is 87% to 100%.\(^7,28,36\) The relative paucity of intraabdominal fat in children decreases the visualization of periappendiceal inflammatory changes, and contrast-enhanced protocols should be used to maximize diagnostic yield.

Ultrasoundography

Graded compression ultrasonography is conducted by applying pressure at and around the point of maximum abdominal tenderness. Ultrasonographic findings highly associated with appendicitis include an enlarged, tender appendix greater than 6 mm in diameter with enhancing (hyperechoic) surrounding fat.\(^24\) Other signs include an inability to compress the appendix, the presence of periappendiceal fluid, and hypervascularity (Fig. 39.2). Formal ultrasonography for appendicitis has demonstrated sensitivities of 78% to 87% and specificities of 81% to 93% in nongravid adults.\(^23-28\) Accuracy is reduced by a thick abdominal wall and intestinal tract; consequently, ultrasonography is best used in thin patients and in children. It is the initial imaging test of choice in pregnant women and children, in whom one wishes to avoid radiation exposure. Ultrasonography is of added benefit when lower abdominal pain may be of pelvic etiology in women of childbearing age.

In children, the sensitivity and specificity of ultrasonography for the diagnosis of appendicitis range from 78% to 100% and 88% to 98%, respectively.\(^26,36\)

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**Fig. 39.1** Plain abdominal radiography and computed tomography demonstrating appendicitis. **A,** The plain film shows an appendiceal fecalith (arrow) overlying the iliac crest. **B,** Computed tomography with oral contrast enhancement demonstrates an enlarged, fluid-filled appendix (arrow, **B**) and a fecalith with periappendiceal inflammation (arrow, **C**).
Intravenous administration of isotonic crystalloid should be initiated as indicated, particularly if prolonged vomiting, anorexia, or fever has been reported. In anticipation of surgery, the patient should be advised not to eat or drink.

Control of pain and nausea is both medically rational and humane. Narcotic administration has not been shown to affect the sensitivity of the physical examination in either adults or children or delay the time to diagnostic decision making, although adequately powered studies in children are lacking.

Analgesia with morphine sulfate, hydromorphone, or fentanyl is appropriate. An antiemetic, such as ondansetron, promethazine, prochlorperazine, or metoclopramide, may also be required.

Prophylactic administration of antibiotics has been shown to reduce perioperative infection rates in both simple (nonperforated) and complicated (perforated or gangrenous) appendicitis.

Their administration should be timed in consultation with the surgeon so that high antibiotic tissue levels coincide with the surgical procedure. The antibiotics should be effective against both skin flora and common appendiceal pathogens, including Escherichia coli, Klebsiella, Proteus, and Bacteroides species (Table 39.4).

Emergency sonography is compelling because it does not require radiation exposure and can be performed rapidly at the bedside by the clinician. However, large variations in sensitivity (65% to 96%), probably related to operator experience, reduce its current utility as a reliable diagnostic tool.

Combined Ultrasound and Computed Tomography Protocols

CT is more sensitive and specific for the diagnosis of appendicitis than ultrasound is in both adult and pediatric populations, and the accuracy of ultrasound is highly operator dependent. However, concern regarding radiation exposure—especially in children—has led to the implementation of protocols involving ultrasound and then CT in which only patients with negative or nondiagnostic findings on ultrasound undergo CT. This serial diagnostic approach has been applied to both adults and children, with sensitivities and specificities ranging from 94% to 100% and 86% to 94%, respectively. Concerns that delays in definitive therapy associated with serial imaging protocols could cause an increase in the rate of perforated appendicitis have not been validated.

Magnetic Resonance Imaging

Findings on magnetic resonance imaging (MRI) in patients with appendicitis consist of a thickened appendiceal wall, a dilated lumen filled with high-intensity material, and periappendiceal enhancement on T2-weighted images. The utility of MRI in diagnosing appendicitis is curtailed by its limited availability, higher cost, and longer image acquisition time. MRI may be appropriate in patients in whom radiation exposure is contraindicated and ultrasonography is nondiagnostic.

Early surgical consultation should be obtained whenever appendicitis is suspected (Box 39.3). Delays in surgery raise the risk for appendiceal perforation, peritonitis, and sepsis. Children, pregnant women, and elderly patients with abdominal pain have especially atypical manifestation and are at higher risk for perforation. Surgical consultation should not be delayed for testing, and testing should be undertaken only when the clinical diagnosis is in question.

Intravenous administration of isotonic crystalloid should be initiated as indicated, particularly if prolonged vomiting, anorexia, or fever has been reported. In anticipation of surgery, the patient should be advised not to eat or drink.

Control of pain and nausea is both medically rational and humane. Narcotic administration has not been shown to affect the sensitivity of the physical examination in either adults or children or delay the time to diagnostic decision making, although adequately powered studies in children are lacking. Analgesia with morphine sulfate, hydromorphone, or fentanyl is appropriate. An antiemetic, such as ondansetron, promethazine, prochlorperazine, or metoclopramide, may also be required.

Prophylactic administration of antibiotics has been shown to reduce perioperative infection rates in both simple (nonperforated) and complicated (perforated or gangrenous) appendicitis. Their administration should be timed in consultation with the surgeon so that high antibiotic tissue levels coincide with the surgical procedure. The antibiotics should be effective against both skin flora and common appendiceal pathogens, including Escherichia coli, Klebsiella, Proteus, and Bacteroides species (Table 39.4).

Patients in whom the findings are a concern despite normal laboratory and imaging results should be admitted for observation and serial abdominal examinations (Box 39.4).
appendicitis, and negative diagnostic evaluation results may be considered for discharge if their clinical symptoms improve and they are able to tolerate oral fluids. Arrangements should be made for close follow-up for such patients, who should be given specific instructions to return to the ED if their symptoms worsen. Antibiotics should not be prescribed for discharged patients with undifferentiated abdominal pain. Narcotic analgesics may mask disease progression and are not recommended.

### Table 39.4 Options for Preoperative Antibiotics in Patients Suspected of Having Appendicitis

<table>
<thead>
<tr>
<th>Adults</th>
<th>Uncomplicated (nonperforated)</th>
<th>Cefoxitin or cefotetan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perforated or gangrenous appendicitis</td>
<td>A carbapenem</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ticaricillin-clavulanate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Piperacillin-tazobactam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ampicillin-sulbactam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A fluoroquinolone (ciprofloxacin, levofloxacin, metronidazole)</td>
</tr>
<tr>
<td>Children</td>
<td>Ampicillin, gentamicin, metronidazole</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ampicillin, gentamicin, clindamycin</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A carbapenem</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ticaricillin-clavulanate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Piperacillin-tazobactam</td>
<td></td>
</tr>
</tbody>
</table>

### BOX 39.4 Disposition of Patients with Undifferentiated Abdominal Pain

Admit for observation if:
- Suspicion for appendicitis or another urgent intraabdominal process is high despite negative test results.
- Poor follow-up is likely.
- Oral intake is impaired.

Discharge home if:
- Good follow-up can be arranged and there are no impediments to obtaining care.
- The patient is able to tolerate oral fluids.

Discharge considerations:
- Instruct the patient to return to the emergency department for increasing pain, fever, nausea, vomiting, or anorexia.
- Do not prescribe narcotic analgesics.
- Do not prescribe antibiotics.

### RED FLAGS

In geriatric or female patients with right lower quadrant pain, the misdiagnosis rate can be as high as 40%.

In the pediatric age group, misdiagnosis of appendicitis approaches 50%.

The incidence of diarrhea in children younger than 3 years with acute appendicitis is 33%.

### TIPS AND TRICKS

If a patient is discharged with the diagnosis of acute abdominal pain, ensure that the plan for that patient is clear and specific. Ask the patient or caregiver to repeat the explained plan. Be sure to include the time and place of the repeat abdominal examination.

Check that the β-human chorionic gonadotropin level is determined in all female patients of childbearing age.

Be certain that the imaging study demonstrates a normal appendix to exclude the diagnosis. Caution should be used when attributing pain to an ovarian cyst or uterine fibroid discovered on ultrasound.

### DOCUMENTATION

Include the following elements in your documentation:
- Initial physical examination and serial abdominal examinations
- Differential diagnosis of the patient’s abdominal pain
- Discussions with consultants, patient, and family members

If a patient with unexplained abdominal pain is discharged, explain why you concluded that the patient did not have acute appendicitis. Include laboratory results, imaging studies, serial examinations, and consultations.

Document in the discharge instructions when the patient with unexplained abdominal pain should undergo a repeat abdominal evaluation: 8, 12, 24, or 36 hours.

### SUGGESTED READINGS


### REFERENCES

References can be found on Expert Consult @ www.expertconsult.com.
REFERENCES